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(54) Title: ABRASIVE PRODUCT WITH REDUCED PARTICLE CONCENTRATION**(57) Abstract**

An abrasive product comprises a multitude of metal deposits on a substrate. The metal deposits bear particulate abrasive material, preferably diamond grit, and the percentage coverage of the total area of the substrate by the deposits is less than about 25 %, preferably 20 %. It has been unexpectedly found that a reduction in the percentage coverage relative to normal practice in the art leads to an improvement in abrasion rate.

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ABRASIVE PRODUCT WITH REDUCED PARTICLE CONCENTRATION

This invention relates to an abrasive product of the type comprising a multitude of metal deposits, preferably electrodeposits, formed on a substrate. The metal deposits 5 bear particulate abrasive material, such as diamond grit.

In European Patent Application No. 0263785, published on April 13, 1988, a technique is described for manufacturing abrasive products by electrodepositing nickel through a mask onto a conductively rendered fabric in the presence of diamond grit 10 so as to form a multitude of abrasive particle-bearing deposits on the underlying fabric. The described product has met substantial commercial success in the abrasive industry, particularly for stone and glass applications. While retaining good flexibility, the product will last many times 15 longer than conventional abrasives.

Canadian Patent Application Nos. 530,811; 531,996; 549,901; 552,387; and 556,049; describe various techniques for carrying out the deposition process on a fabric or other substrate. In a preferred embodiment, a metal foil is attached to a 20 substrate and photographically masked. Nickel is then deposited on the metal foil, preferably a copper foil, through apertures in the mask in the presence of diamond grit, which then becomes embedded in the nickel deposits. After electrodeposition, the mask is stripped away, the copper 25 between the deposits etched away in an acid bath, and the resulting voids filled with resin preferably containing silicone carbide as a filler.

These products have generally been remarkably successful.

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According to the present invention there is provided in a abrasive product comprising a multitude of metal deposits on a substrate, said metal deposits bearing particulate abrasive material, the improvement wherein the percentage coverage of 5 the total area of the substrate by said deposits is less than about 25%.

The percentage coverage can be less than about 20%, preferably in the range of about 12 to 18 percent. It can be desirable to vary the pattern of deposits on the substrate.

10 It has been found particularly desirable to arrange the deposits in triangular groups of three, diamond-shaped groups of four, or in a diagonal configuration.

15 The present invention is based on the remarkable and totally unexpected result that a significant reduction in the percentage coverage of the substrate below normal practice in the art, and what would be expected by a skilled person, can actually lead to an improvement in abrasive performance, or at least such a reduction does not bring about an expected gradual deterioration in performance. Even the latter result 20 is useful because the abrasive material, generally diamond grit, is proportionately the most expensive component of the product. The ability to reduce the amount of diamond employed permits substantial cost savings. It was totally unexpected that the diamond coverage could be reduced in this way without 25 significantly impairing product performance.

It would be expected that a gradual reduction in the concentration of abrasive material would bring about a concomitant reduction in abrasive performance. While the reason that this does not occur is not absolutely clear, it

is believed that at normal concentrations there is a tendency for the abrasive particles protruding above the surface of the deposits to wear down in such a way that their tips become rounded because the frictional force between the work piece
5 and the abrasive product is spread out over a larger number of abrasive particles. As the number of abrasive particles is reduced, the frictional force is borne by a smaller number of particles, and this creates a tendency for the particles to micro-fracture, creating jagged edges that have good
10 abrasive properties.

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings, in which:-

15 Figure 1 is a sectional view of an abrasive product with normal surface coverage;

Figure 2 is a section taken through an abrasive product having reduced surface coverage;

20 Figure 3 shows the results of tests measuring the material removal rate against the number of samples abraded by a belt having normal surface coverage and one having reduced surface coverage;

Figure 4 shows the results of tests measuring the material removal rate against time for products with normal and reduced coverage;

25 Figures 5a to 5e show various deposit patterns employed in abrasion tests;

Figure 6 is a graph showing glass removal rate against time for abrasive products having different surface coverage and surface patterns as shown in Figures 5a to 5b;

5 Figure 7 shows an abrasive disk consisting of a plurality of segments, each segment having the deposits laid out in a predetermined pattern; and

10 Figure 8 is a graph showing the amount of substance removed against time for an abrasive having a normal distribution of diamond particles and one having the particle distribution reduced by one third.

The abrasive product shown in Figure 1 comprises a woven Kevlar™ fabric substrate 1. Nickel electrodeposits 4 are formed on disks 2 of copper foil resin-bonded to the Kevlar™ substrate 1. The nickel deposits 4 have diamond grit particles 5 embedded therein. The deposits 5 are generally circular, about 1/16th inch in diameter, although they can have other shapes as described in the above referenced co-pending applications, and diameters of up to about 1/4 inch.

The voids between the deposits 4 are filled with polyurethane resin 3 containing silicone carbide as a filler. This reduces the shearing forces on the deposits and helps to keep them in place during the abrasion process.

25 The fabrication of this product is described in the above-referenced co-pending applications. First, a copper foil is bonded to the woven Kevlar™ substrate by Lomod™ resin. A surface mask is then photographically applied and

the nickel electrodeposited through the mask onto the copper foil in the presence of the diamond grit. Finally, the mask is stripped away with sodium hydroxide solution and the residual foil between the deposits etched away with acid. The
5 voids are then back-filled with the resin.

The above-referenced copending applications describe an improved technique for fabricating a product having diamond grit attached to some form of substrate by means of nickel electrodeposits. Other techniques for making abrasive
10 products with diamond-bearing nickel deposits are known. For example US Patent No. 4,256,467 to Interface describes a technique for forming electrodeposits by depositing through a non-conductive mesh. U.S. Patent No. 4,047,902 to Wiand describes a technique forming electrodeposits onto a
15 substrate. In these products, and indeed the products made in accordance with the techniques described in the above-referenced co-pending applications, it has been conventional practice, and it was thought natural and necessary, to have a relatively high percentage coverage of
20 the total area of the abrasive product. In practice, the surface coverage has been at least about one-third. The commercial product of the present applicants has a coverage of about 32.2%. Experience with other types of conventional abrasives suggested that a surface coverage of this nature
25 would be necessary, and it was not considered practical to reduce the surface coverage beyond this level because the amount of diamond grit available for abrasion would be limited and the expected results poor.

Quite unexpectedly, it has been found that, on the contrary,
30 a reduction in surface coverage in some cases actually improves the abrasive performance, and more generally, over

quite a wide range, leads to no, or at the very least little, reduction in abrasive performance.

The reason why this happens is not absolutely clear, but it is believed that with higher diamond concentrations, because 5 the frictional load is spread out over a larger number of diamond particles, the frictional forces tend to wear down the particles 5 so that they become rounded, as illustrated in Figure 1.

Figure 2 shows an abrasive product similar to the product of 10 Figure 1, but with reduced surface coverage of nickel deposits. As will be seen in Figure 2, the deposits 5 are shown as having jagged edges. It is believed that what happens at reduced diamond concentration is that the frictional forces, instead of causing wear of the diamond 15 particles 5, cause micro-fractures to occur which lead to jagged edges. These abrade better than rounded tips and thereby tend to improve abrasive performance.

In a first set of experiments, abrasive belts made by the techniques described in the above-referenced copending 20 applications were used to remove material from a glass work-piece. The belts had pellets arranged in a regular diagonal pattern, relative to the direction of movement for the belt, the deposits being approximately one-sixteenth of an inch in diameter and having a surface coverage of about 25 32.2%. In a first set of experiments, one out of every three deposits was removed with a knife, and the belts used to abrade a series of sample workpieces.

The results as shown in Figure 3 where the material removal rate (MRR) is plotted against the number of samples abraded

by the belt. The crosses represent the standard belts and the full squares represent belts with reduced surface coverage. It can be seen that the performance of the reduced coverage belts is substantially better than the belts with normal 5 surface coverage and that the belts with reduced coverage can abrade more samples.

Figure 4 shows similar results, where the MRR is plotted against time. The MRR for the belts with reduced coverage, i.e. having approximately one-third less coverage than the 10 normal belts, is substantially better than the MRR for the normal belts.

Figure 5a shows the deposit pattern for a normal belt having full coverage, i.e. 32.2%. Figures 5b to 5e show alternate patterns for belts with reduced coverage. The percentage 15 surface coverage is as follows:

Figure	Percentage
5b	15.2%
5c	12.78%
5d	17.04%
20 5e	16.74%

Experiments were conducted with belts having the deposit patterns shown in Figures 5a to 5e. A glass plate one-quarter of an inch in thickness was abraded under dry conditions with Kevlar™ belts one and one-eighth inch wide by twenty-one 25 inches long, having a grit size of 220.

The results are shown in Figure 6, where the glass removal rate in grams per minute is plotted against time. In Figure

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6, the filled squares represent the results obtained with the normal belts shown in Figure 5, the crosses the results obtained with the triangular configuration shown in Figure 5b, the diamonds, the results with the diagonal configuration 5 shown in Figure 5c, the filled triangles, the results with the diamond configuration shown in Figure 5d, and the x's the results obtained with the full diagonal pattern shown in figure 5e.

10 The results shown in Figure 6 are extremely interesting. The best results are obtained with the pattern shown in Figure 4, where the surface coverage was 17.04%. This is about half the surface coverage that had been previously employed.

15 The worst results are obtained with the higher diamond concentration, as indicated by the full squares. Good results, considerably better than those obtained with the Figure 5a configuration, are obtained with the triangular configuration of Figure 5b, where the surface coverage was only 15.2%. It is a quite remarkable result that halving the concentration of diamond grit can actually lead to a three-fold increase in glass removal rate after the first half hour. 20 The ability to reduce the diamond coverage by a factor of 2 very substantially reduces the cost of the product.

Figure 7 shows an abrading disk, which also takes advantage 25 of this result. The disk comprises shaped segments 10 uniformly spaced on a substrate 11, which between the segments is clear of any deposits. The surface coverage within the segments can be reduced in the manner described above, leading to an overall surface coverage that is even less than for a belt having a uniform pattern over the whole surface. The size 30 of the deposits is about 1/4 inch.

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Figure 8 shows the results of further experiments and confirms the advantages of using a reduced diamond particle concentration.

While the invention has been described with reference to 5 diamond particles deposited on a copper substrate and embedded in nickel, other suitable materials may be employed. The diamond particles may be replaced by cubic boron nitride or other suitable particulate material as described in the above-referenced applications, and compatible materials other 10 than copper and nickel may be employed, depending on the application.

Generally the cut off point varies down to about 25% of the whole area or of a given area. Good results are obtained with a 50% reduction in concentration over conventional products.

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Claims:

1. An abrasive product comprising a multitude of metal deposits on a substrate, said metal deposits bearing particulate abrasive material, characterized in that the 5 percentage coverage of the total area of the substrate by said deposits is less than about 25%.
2. An abrasive product as claimed in claim 1 characterized in that said percentage coverage is less than about 20%.
3. An abrasive product as claimed in claim 1 characterized 10 in that said percentage coverage lies in the range of about 12% to 18%.
4. An abrasive product as claimed in claim 3 characterized in that said metal deposits are arranged in a regular pattern.
5. An abrasive product as claimed in claim 4 characterized 15 in that said metal deposits are arranged in a diagonal pattern.
6. An abrasive product as claimed in claim 4 characterized in that percentage coverage is about 13%.
7. An abrasive product as claimed in claim 4 characterized 20 in that said metal deposits are arranged in a regular pattern of groups.
8. An abrasive product as claimed in claim 6 characterized in that each said group comprises three deposits in a triangular configuration.

9. An abrasive product as claimed in claim 8 characterized in that the percentage coverage is about 15%.
10. An abrasive product as claimed in claim 7 characterize in that each said group comprises four deposits in a square configuration.
11. An abrasive product as claimed in claim 10 characterized in that the percentage coverage is about 17%.
12. An abrasive product as claimed in any one of claims 1 to 3 characterized in that the percentage coverage lies in the range 15 to 18%.
13. An abrasive product as claimed in claim 1 characterized in that the particulate abrasive material is diamond grit.
14. A method of making an abrasive product comprising electrodepositing metal onto a substrate through a mask while embedding particulate abrasive material therein, and forming a pattern of electrodeposits on said substrate characterized in that the percentage coverage of the total surface area of said substrate by said deposits is less than about 25%.
15. A method as claimed in claim 13 characterized in that the percentage coverage is less than about 20%.
16. A method as claimed in claim 13 characterized in that the percentage coverage lies in the range of about 12 to 18%.
17. A method as claimed in claim 14 characterized in that the particulate abrasive material is diamond grit.

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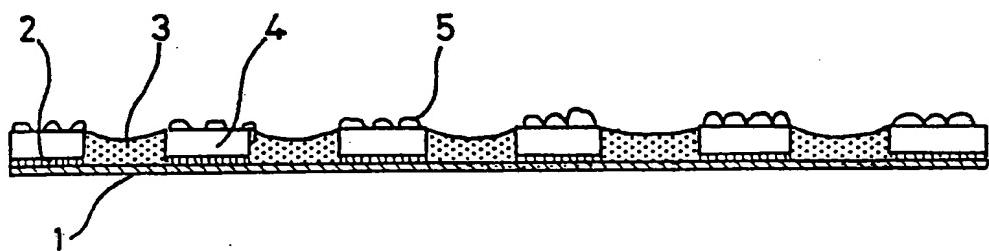


Fig. 1
PRIOR ART

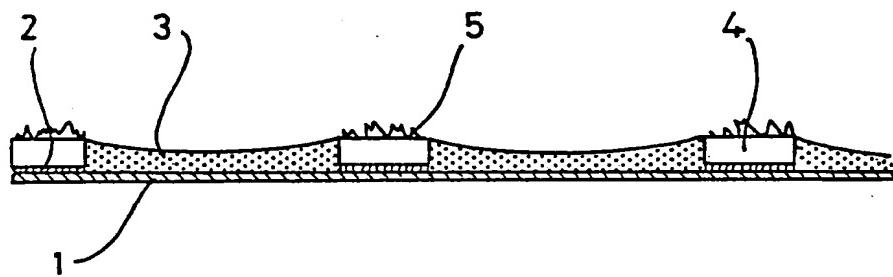
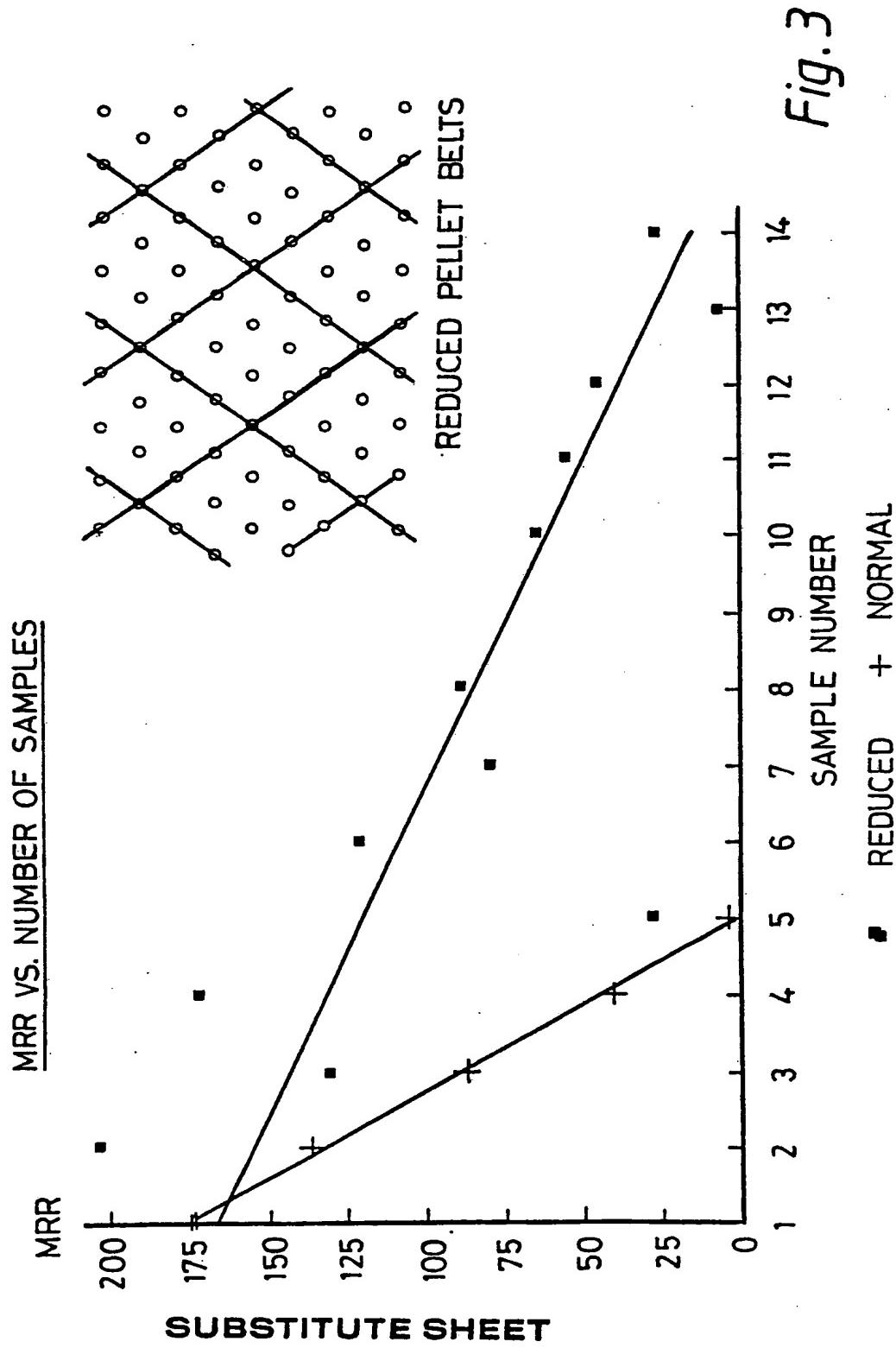


Fig. 2

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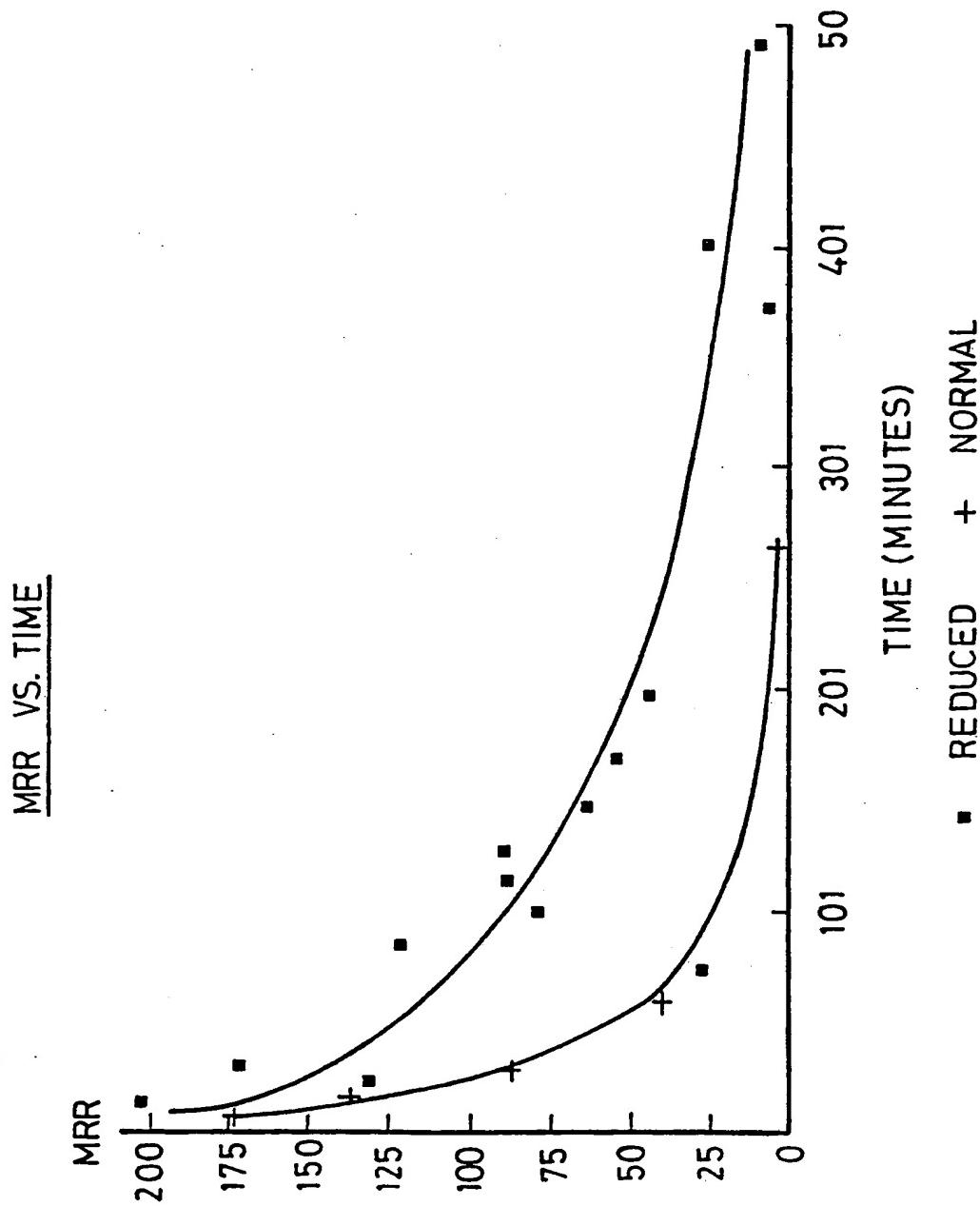
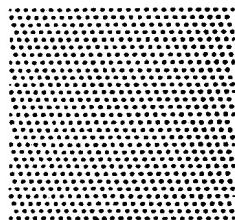


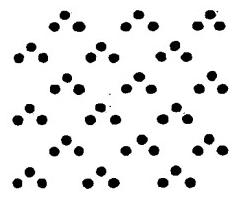
Fig. 4

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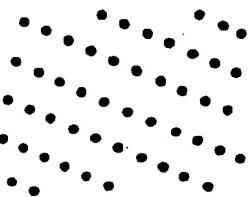
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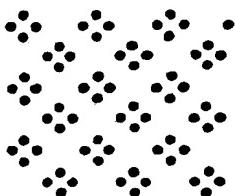
FULL

Fig. 5a

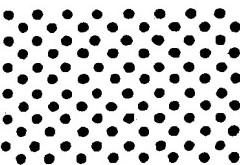
THREE

Fig. 5b

DIAGONAL

Fig. 5c

FOUR

Fig. 5d

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*Fig. 5e***SUBSTITUTE SHEET**

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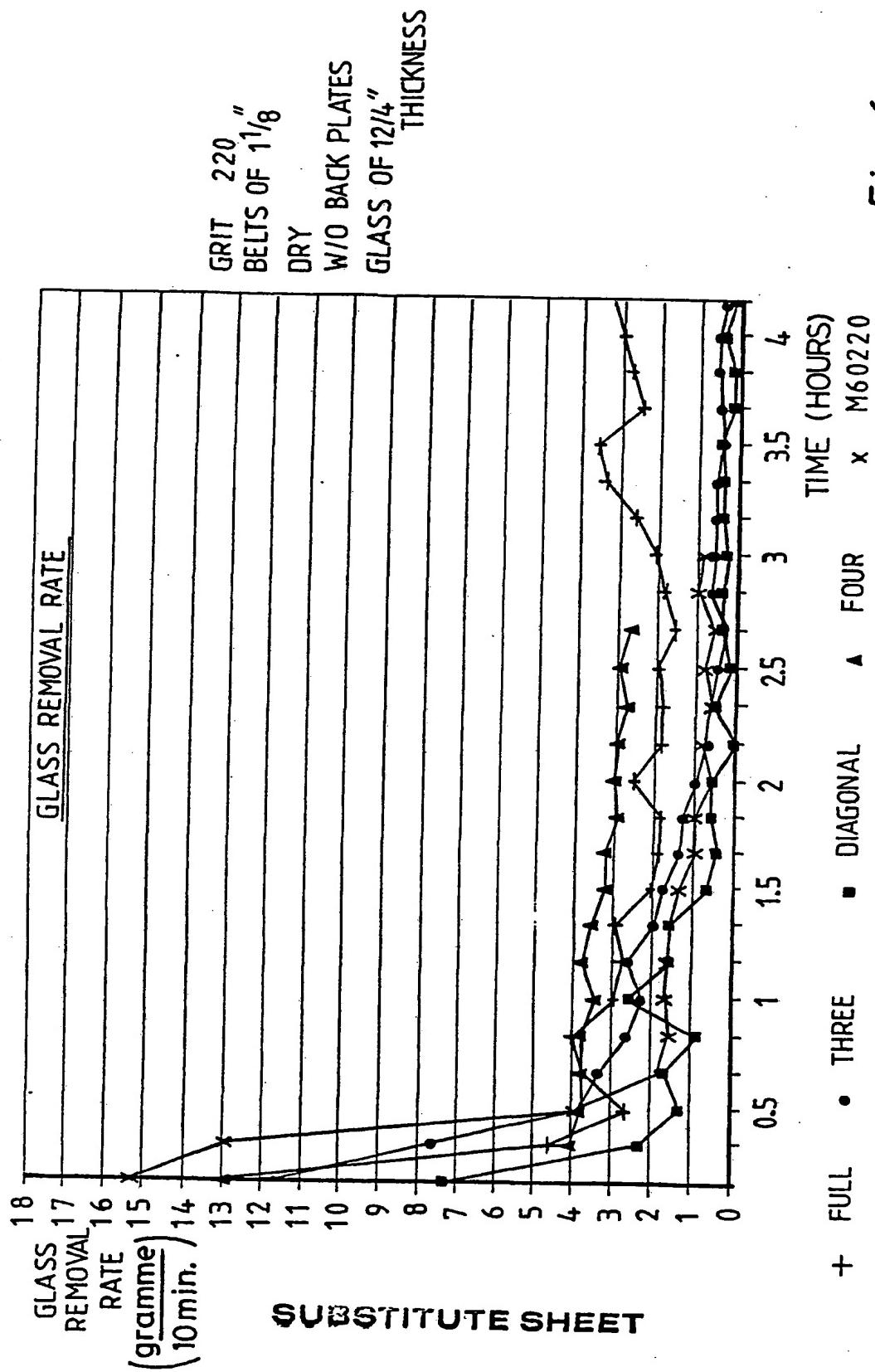


Fig. 6

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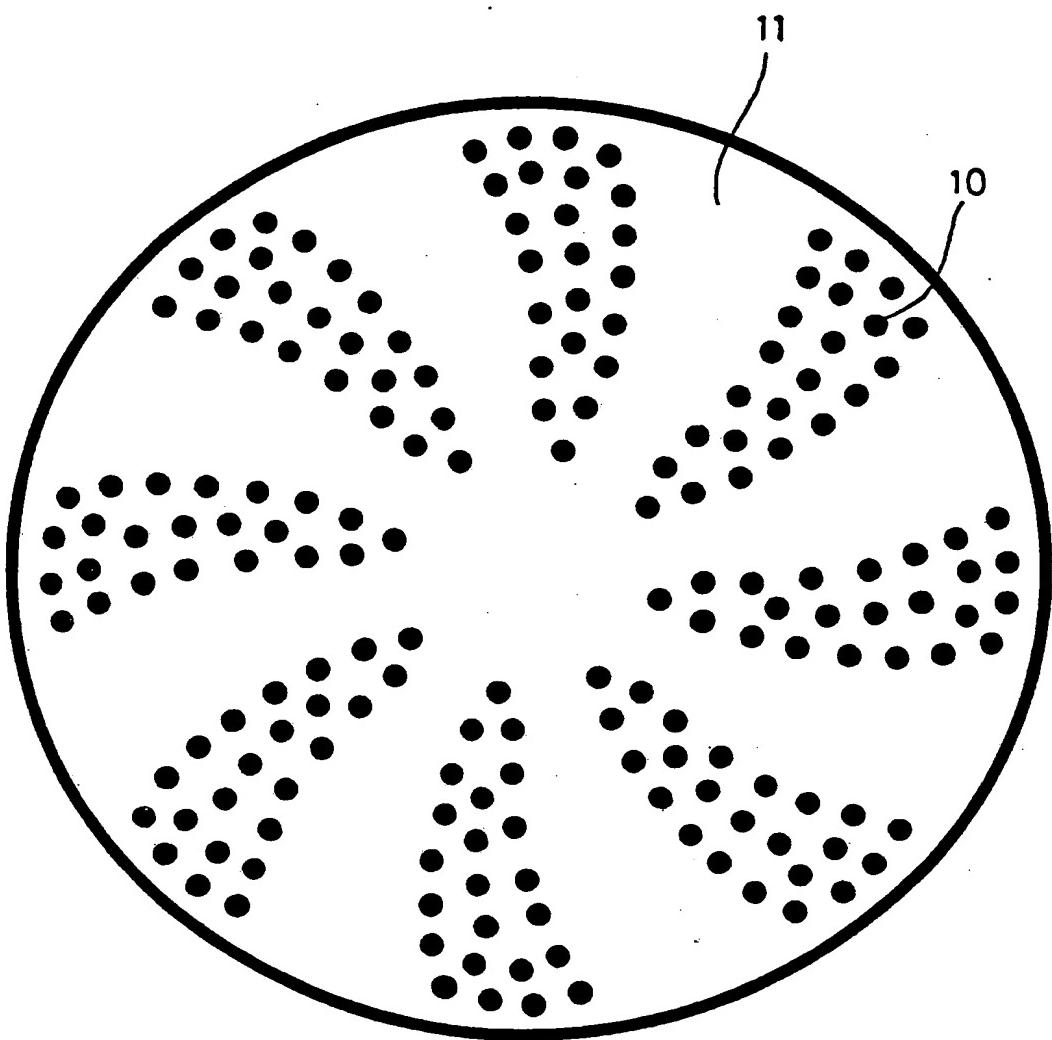


Fig. 7

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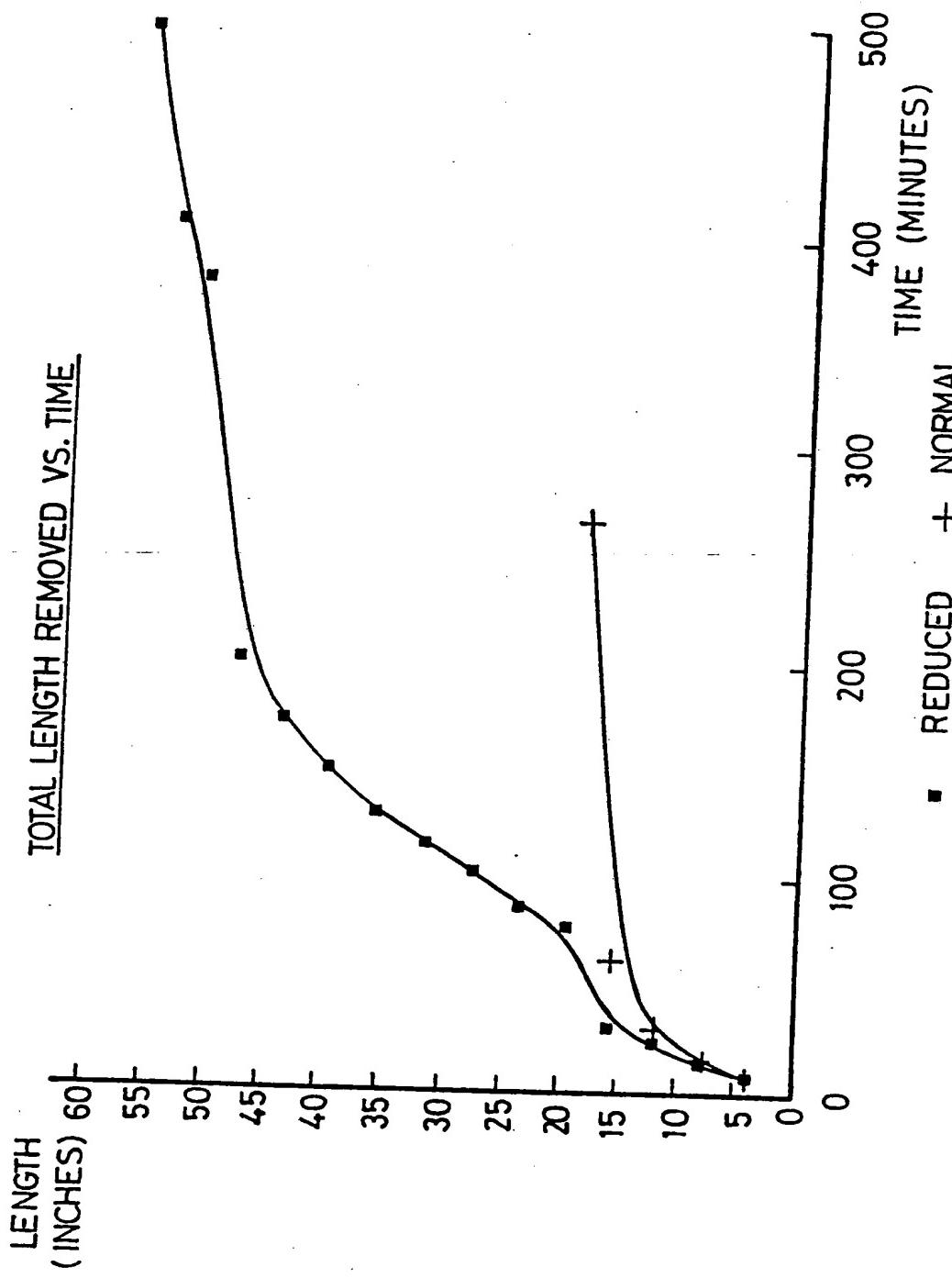


Fig. 8

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INTERNATIONAL SEARCH REPORT

International Application No.

PCT/GB 89/00728

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) *

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC⁵: B 24 D 11/00, B 24 D 3/00, B 24 D 3/06

II. FIELDS SEARCHED

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Classification System	Classification Symbols
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Documentation Searched other than Minimum Documentation
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III. DOCUMENTS CONSIDERED TO BE RELEVANT*

Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
Y	US, A, 4047902 (R.K. WIAND) 13 September 1977, see claims 1-6; figures 1,2 (cited in the application) --	1-17
Y	FR, A, 1400574 (SPAM) 1965, see figures 1-3; claims 1-6 --	1-17
A	US, A, 2743559 (A.L. BALL) 1 May 1956, see claims 1-8; figures 1-5 --	1-17
A	Patent Abstracts of Japan, vol. 8, no. 120 (M-300)(1557) 6 June 1984; & JP, A, 5924965 (HARUMITSU YASUDA) 8 February 1984 --	1-17
Y	US, A, 4555250 (SHOWA DENKO K.K.) 26 November 1985, see figures 1-4B; claim 19 --	1-17
A	US, A, 3991527 (BATES ABRASIVE PRODUCTS) 16 November 1976, see figures 1-12; abstract -----	1-17

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IV. CERTIFICATION

Date of the Actual Completion of the International Search

14th September 1989

Date of Mailing of this International Search Report

16 OCT. 1989

International Searching Authority

EUROPEAN PATENT OFFICE

Signature of Authorized Officer

T.K. WILLIS

BEST AVAILABLE COPY**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**GB 8900728
SA 29807

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 10/10/89. The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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		FR-A, B	2361199	10-03-78
		JP-A-	53000488	06-01-78
		SE-A-	7707223	25-12-77
FR-A- 1400574		None		
US-A- 2743559		None		
US-A- 4555250	26-11-85	JP-A-	58090468	30-05-83
US-A- 3991527	16-11-76	None		